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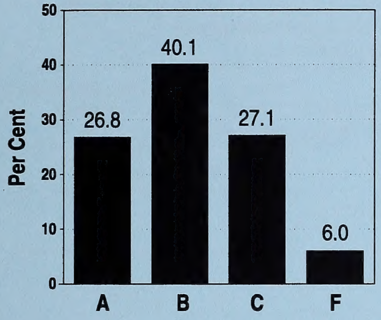
Physics 30

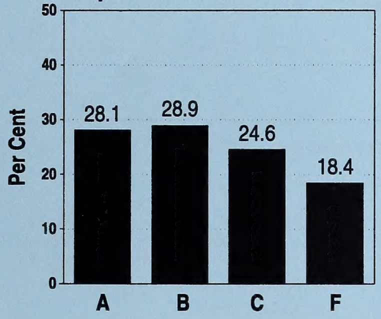
Diploma Examination Results
Examiners' Report for January 1993

CANADA
APR 26 1993

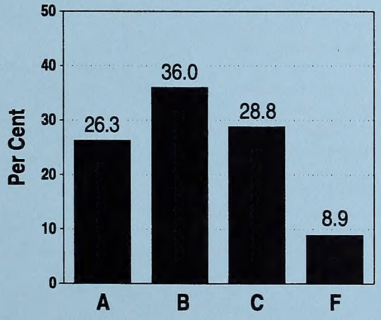
School-Awarded Mark



Diploma Examination Mark



Final Course Mark



The summary information in this report provides teachers, school administrators, students, and the general public with an overview of results from the January1993 administration of the Physics 30 Diploma Examination. This information is most helpful when used in conjunction with the detailed school and jurisdiction reports that have been mailed to schools and school jurisdiction offices. An annual provincial report containing a detailed analysis of the combined January, June, and August results is published each year.

Description of the Examination

The Physics 30 Diploma Examination consists of three parts: a multiple-choice section of 42 questions worth 60%, a numerical-response section of seven questions worth 10%, and a written-response section of four questions worth 30% of the total examination mark.

Achievement of Standards

The information reported is based on the final course marks achieved by 3 333 students who wrote the January 1993 examination.

- 91.1% of these students achieved the acceptable standard (a final course mark of 50% or higher).
- 26.3% of these students achieved the standard of excellence (a final course mark of 80% or higher).

Overall, student performance in Physics 30 was satisfactory. Students' problem-solving skills continued to improve and they showed a good understanding of course content.

Provincial Averages

- The average school-awarded mark was 69.8%.
- The average diploma examination mark was 66.8%.
- The average final course mark, representing an equal weighting of the school-awarded mark and the diploma examination mark, was 68.8%.

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Subtest

When analyzing detailed examination results, please bear in mind that subtest results **cannot** be directly compared.

Results are in average raw scores.

Machine scored: 34.6 out of 49

Course Content
- Light: 7.8 out of 11
- Electric and Magnetic Fields: 8.7 out of 12
- Electromagnetic Radiation: 5.6 out of 8
- Structure of Matter: 5.5 out of 8
- Modern Physical Theories: 7.1 out of 10

Process Skills: 12.0 out of 19
- Multiple-choice questions 2, 3, 7, 8, 10, 16, 20, 24, 28, 34, 35, 36, 37, and 39; numerical-response questions 2, 3, 4, 5, and 6

Cognitive Levels
- Knowledge: 12.9 out of 17
- Comprehension and Application: 14.9 out of 21
- Higher Mental Activities: 6.9 out of 11

Written response: 12.1 out of 21

Process Skills: 12.1 out of 21
- Written-response questions 1, 2, 3, and 4

Examination Blueprint

Each question on the examination is classified in two ways: according to the curricular content area being tested and according to the cognitive level demanded by the question. The examination blueprint illustrates the distribution of questions in January 1993 according to these classifications. Numbers with parentheses ( ) indicate numerical-response questions; the others are multiple-choice questions.

	Multiple-Choice and Numerical-Response Questions by Cognitive Level			
Cognitive Level	**Knowledge**	**Comprehension and Application**	**Higher Mental Activities**	**Examination Emphasis (%)**
Light	1, 4, 5, 6	9, 10; (1)	2, 3, 7, 8	16
Electric and Magnetic Fields	11, 13, 14, 19	12, 15, 16, 17, 18, 21	20; (2)	17
Electromagnetic Radiation	22, 25, 27	23, 24, 26; (3), (4)		10
Structure of Matter	29, 30, 32	31, 33	28, 34; (5)	13
Modern Physical Theories	40, 41, 42	36, 37, 38, 39; (7)	35; (6)	14
Examination Emphasis (%)	**24**	**30**	**16**	**70**

	Written-Response Section	
Question Number	**Question Description (Concept, Cognitive Levels, and Process Skills)**	**Mark Value**
1	30.1.1 30.1.2 Comprehension and Application Recognize which variables need to be identified and relationship between the variables. Describe quantitatively the relationships between distance, time, speed, index of refraction.	5
2	30.2.3 Comprehension and Application; Higher Mental Activities Produce two graphs, recognize relationships between power, current, and resistance.	7
3	30.4.3 Comprehension and Application Calculate a missing variable. Describe quantitatively the relationships between work function, speed, and stopping voltage.	5
4	30.3.1 30.3.4 Higher Mental Activities Interpret given information. Draw diagram to demonstrate reflection and explain.	4
	Total	**21**

This examination has a balance of question types and difficulties. It is designed so that students capable of achieving the acceptable standard will obtain a mark of 50% or higher and students capable of achieving the standard of excellence will obtain a mark of 80% or higher. This examination again included numerical-response questions, which students handled very well. Students achieving the acceptable standard were expected to show good communication skills in the written-response section of the examination, regardless of whether their answers were in calculation or verbal form.

The examination marks of males and females on this examination administration were almost identical—66.76% for male students and 66.79% for female students. On individual items, however, there were often marked differences between the performance of males and the performance of females. We plan to analyze these variations in greater detail and publish our conclusions in the annual provincial report.

Multiple Choice

Question	Key	Difficulty*
1	B	80.1
2	B	78.8
3	C	58.7
4	D	88.4
5	C	79.3
6	B	75.8
7	A	42.8
8	D	50.8
9	C	86.0
10	C	64.3
11	B	78.9
12	D	59.2
13	A	68.7
14	D	74.1
15	C	75.5
16	A	40.9
17	D	86.1
18	B	77.2
19	A	83.6
20	A	62.6
21	D	85.8
22	D	85.1
23	A	53.6
24	B	68.5
25	D	72.0
26	C	59.9
27	D	81.5
28	B	74.6
29	A	78.9
30	D	74.2
31	B	75.8
32	B	64.0
33	C	77.6
34	C	47.1
35	A	75.2
36	C	60.4
37	D	84.5
38	B	83.7
39	A	63.6
40	C	67.2
41	A	84.4
42	D	53.6

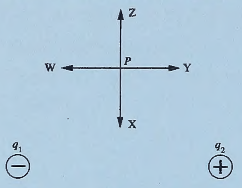
*Difficulty—percentage of students answering the question correctly

Multiple Choice and Numerical Response

All students were expected to demonstrate a high level of competence in calculations. Students achieving the standard of excellence were expected to apply their knowledge to unusual problems and to use scientific generalizations effectively. Students' performance on the machine-scored sections of the examination was generally satisfactory. The average score for the machine-scored sections was 70.7%. Students found the calculation questions to be the easiest. For a complete breakdown of student responses by alternative for the multiple-choice questions, please refer to the school and jurisdiction reports. Detailed comments on selected questions from the multiple-choice and numerical-response sections follow.

Multiple Choice

Electric Field from Two Point Charges



In the diagram, q_1 and q_2 are charges of equal magnitude but opposite sign. Point P is equidistant from q_1 and q_2.

16. The direction of the net electric field at point *P* is the same as direction

● **A.** W
B. X
C. Y
D. Z

In **question 16,** students had to determine the direction of the resultant electric field arising from two point charges. Students achieving at the acceptable standard were expected to be able to determine the field direction from a single point charge or to add two vectors at right angles, but were expected to have difficulty in combining the two steps. Students achieving at the standard of excellence were expected to combine the two steps to answer this question. Of the students who achieved the acceptable standard but not the standard of excellence, 35.7% answered this question correctly. Of the students who achieved the standard of excellence, 67.1% answered this question correctly.

31. A television picture tube operates with a potential difference of 3.0×10^4 V. If X-rays are emitted from this picture tube, the minimum wavelength of the X-rays would be

A. 7.2×10^{18} m
● **B.** 4.1×10^{-11} m
C. 2.4×10^{10} m
D. 1.0×10^{-4} m

In **question 31,** students had to calculate the minimum wavelength of the X-rays emitted from a leaky TV picture tube. This calculation had two steps, and all students achieving the acceptable standard or higher were expected to answer the question correctly. Of the students who achieved the acceptable standard but not the standard of excellence, 77.2% answered this question correctly. Of the students who achieved the standard of excellence, 92.4% answered this question correctly. Even 46.3% of the students who failed to reach the acceptable standard answered this question correctly.

Numerical Response

Question	Answer	Difficulty*
1	1.44	71.2
2	9.24	75.4
3	8.5	64.3
4	58.5	73.6
5	8.46	61.2
6	2.1	59.6
7	27	74.3

*Difficulty—percentage of students answering the question correctly

Most students correctly followed the instructions for filling in the answer sheet. All seven questions discriminated well between those students who reached an acceptable standard and those who did not. The questions showed that students achieving the acceptable standard can generate a correct response for questions that have an open-ended format.

The frequency and wavelength of an incident wave are determined experimentally to be 2.45×10^9 Hz and 0.112 m respectively. The speed of the electromagnetic wave may be calculated from these data.

3. The percentage error associated with the speed of light calculated from these data is__________ %.

(Round and record your answer to two digits.)

In **question 3,** students had to calculate the percentage error in an experimental determination of the speed of electromagnetic waves in air. They had to calculate the observed speed as 2.74×10^8 m/s and then calculate the percentage error as (observed – expected)/expected, or 8.5%. This question was expected to be easy for students achieving at the standard of excellence but a challenge for those students achieving at the acceptable standard. Of the students who achieved the acceptable standard but not the standard of excellence, 64.6% answered this question correctly. Of the students who achieved the standard of excellence, 87.4% answered this question correctly. Only 28.2% of students who failed to reach the acceptable standard answered this question correctly.

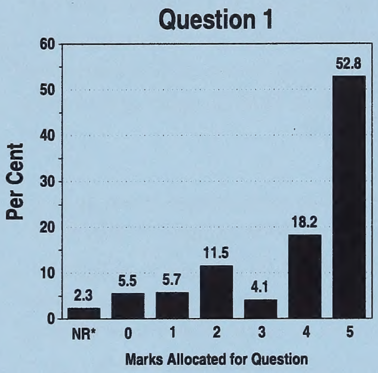
5. One of the energy levels of the hydrogen atom is -1.36×10^{-19} J. The radius of the Bohr orbit corresponding to this energy state is $b \times 10^{-10}$ m. The value of ***b*** is__________.

(Round and record your answer to three digits.)

In **question 5,** students had to calculate the radius of a Bohr orbit in hydrogen, given that the energy of the electron in the orbit was -1.36×10^{-19} J. If this energy were linked to the radius through the formula $E_n r_n = E_1 r_1$ then the final radius was calculated to be 8.48×10^{-10} m. If the energy were used to identify the level as the fourth level, and then the radius taken as exactly 16 times the first Bohr radius, the final radius was calculated to be 8.46×10^{-10} m. Both answers were accepted, and students chose both methods of doing this calculation. This calculation had two steps, and all students achieving the acceptable standard or higher were expected to answer the question correctly. Of the students who achieved the acceptable standard but not the standard of excellence, 62.6% answered this question correctly. Of the students who achieved the standard of excellence, 90.7% answered this question correctly. Only 12.1% of students who failed to reach the acceptable standard answered this question correctly.

Written Response

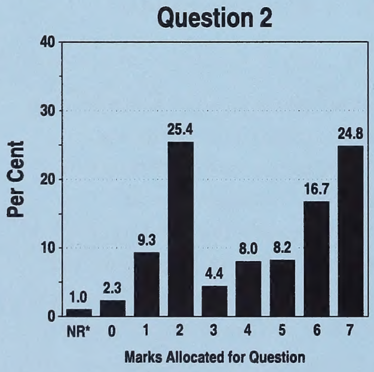
The four questions in the written-response section were created from four of the five strands for Physics 30. Students' problem-solving skills were tested most in *parts b* and *c* of question 2, in *part b* of question 3, and in question 4. Students achieving the acceptable standard on this examination were expected to get 4 out of 5 marks on question 1, 2 out of 7 marks on question 2, 2 out of 5 marks on question 3, and 2 out of 4 marks on question 4. Students performing at the standard of excellence were expected to obtain full marks on question 1, 5 out of 7 marks on question 2, 4 out of 5 marks on question 3, and 3 out of 4 marks on question 4.



NR*–No Response

Question 1 was answered very well by most students. Students had to calculate two path lengths from a diagram and then use these path lengths to calculate the refractive index of a liquid. The second part of the calculation was linked to the first through the equality of the times for both paths. This link was explicitly stated in the caption to the diagram. Most students were able to see the link, to select appropriate equations, and to calculate the refractive index of the liquid. In general, only those few students who did not achieve the acceptable standard were unable to complete this question.

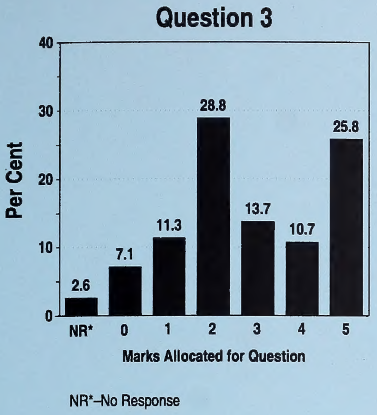
On this 5-mark question, the average mark was 3.78 or 76%.



NR*–No Response

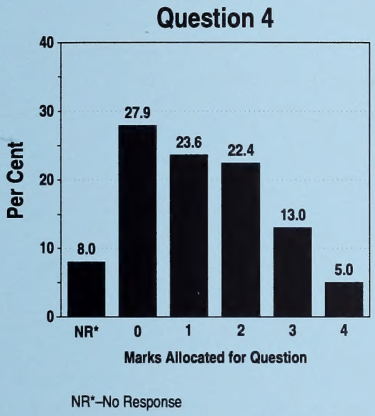
Question 2 was answered better than expected by most students. Students had to draw two graphs, one curved and one straight, in order to summarize data collected in an experiment investigating the power output in an electrical circuit. Based on previous diploma examination questions involving the replotting of graphs, only those students at the standard of excellence were expected to be able to choose appropriate variables to construct a straight line graph from the data given. However, over half the students at the acceptable standard and over 90% of the students at the standard of excellence were able to plot a straight line graph in response to *part b*. It was encouraging to see that students were using the slope as the method of averaging data sets. For the slope to work as an averaging technique, the slope must be significantly different from zero, so graphs of resistance as a function of current could not be averaged by using either slope or data-point averaging methods.

On this 7-mark question, the average mark was 4.20 or 60%.



Question 3 was answered very well by students at the standard of excellence but not by most of the others. Students had to explore the electron energy produced by two different light sources interacting with the same metallic surface. The link between the two parts of the question was that the photoelectric work function was the same in both parts. This link was not stated anywhere in the question or anywhere in the background information. More than 80% of the students at the standard of excellence found this link between the two parts, but fewer than 20% of the other students were able to. Other links that were tried were the placing of work function equal to zero for *part b* and the equality of electron energy in the two parts. Students with improper links between *part a* and *part b* could score a maximum of 3 marks for the question. Students who found the proper link scored either 4 or 5 marks.

On this 5-mark question, the average mark was 2.82 or 56%.



Question 4 was answered in a rough-and-ready manner by most students; few were able to explain the reflection with any degree of precision. Students had to explain the increased distance at which radio stations can be heard at night. It was possible to show that the angle of incidence was equal to the angle of reflection by a well-labeled diagram or by writing a sentence. To explain the increased range of the radio wave at night, it was necessary to state that the angle of elevation of the transmitter had to be the same by day or night. However, very few students did this. A well-laid-out calculation, using invented reasonable numbers, would have made the explanations much clearer. Of the students who achieved the standard of excellence, 39% attempted a detailed, quantitative response to this question. Of the students who achieved the acceptable standard but not the standard of excellence, only 12% attempted such a response.

On this 4-mark question, the average mark was 1.28 or 32%.

For further information, contact Jack Edwards or Phill Campbell at the Student Evaluation Branch, 427-0010.